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Determinants of excessive gestational weight gain in urban, low-income women

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Abstract

Background—Factors influencing excessive weight gain in pregnancy have not been well studied among urban, low-income women.

Methods—Prospective cohort study of 94 prenatal care patients at a large university hospital in Philadelphia, examining associations of modifiable mid-pregnancy behaviors and non-modifiable or early pregnancy factors with excessive gestational weight gain. Data were collected through questionnaires and medical record abstraction in 2009-2011.

Findings—The majority of women were African-American (83%) and all (100%) received Medicaid. Nearly two-thirds (60%) were overweight or obese in early pregnancy and 41% experienced excessive gain. In multivariable logistic regression analyses, significant predictors of excessive gestational weight gain included high early pregnancy body mass index (odds ratio [OR]: 4.20, 95% confidence interval [CI]: 1.43, 12.34 for overweight/obese vs. normal weight), nulliparity (OR: 3.35, 95% CI: 1.17, 9.62 for nulliparity vs. multiparity), and clinician advice discordant with Institute of Medicine guidelines (OR: 5.88, 95% CI: 1.04, 33.32 for discordant vs. concordant advice). Watching under two hours of television daily (OR: 0.18, 95% CI: 0.03, 1.03) and engaging in regular physical activity during pregnancy (OR: 0.35, 95% CI: 0.11, 1.09) were suggestive of a reduced risk of excessive gain.

Conclusions—In this sample of urban, low-income women, high early pregnancy body mass index, nulliparity, and discordant clinician advice were directly associated with excessive

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gestational weight gain, with a trend toward decreased risk for viewing fewer hours of television and engaging in regular physical activity. Intervening on these targets may optimize gestational weight gain and promote long-term maternal health.

Introduction

Pregnancy is an important risk factor for new or persistent obesity among women (Davis, Zyzanski, Olson, Stange, & Horwitz, 2009; Institute of Medicine, 2009; Melzer & Schutz, 2010). Data from the United States (US) National Longitudinal Survey of Youth revealed that parous women were 3 to 4 times more likely to develop obesity in the 5 years after childbirth compared to women without children followed over the same time period (Davis et al., 2009). Consequently, young women are faced with a number of short- and longer-term obesity-related complications, from gestational diabetes mellitus and hypertension in subsequent pregnancies (Villamor & Cnattingius, 2006), to chronic cardiovascular disease, diabetes mellitus, and premature death (Brown, Fujioka, Wilson, & Woodworth, 2009).

High gestational weight gains are the strongest predictor of overweight or obesity following pregnancy (Gunderson & Abrams, 2000; Keppel & Taffel, 1993; Ohlin & Rossner, 1990). Other identified risk factors, including sociodemographic characteristics and modifiable postpartum behaviors (Gore, Brown, & West, 2003; Gunderson et al., 2008; Herring et al., 2008; Oken, Taveras, Popoola, Rich-Edwards, & Gillman, 2007), account for very little of the variability in postpartum weight change. As an attempt in part to decrease the exceedingly high prevalence of obesity among women in the US (Flegal, Carroll, Ogden, & Curtin, 2010), the Institute of Medicine (IOM) revised gestational weight gain guidelines in 2009 (Institute of Medicine, 2009), recommending smaller gains for women with higher pre-pregnancy body mass indices (BMI). However, currently less than one-third of pregnant women achieve guideline recommended gains, with the majority gaining above IOM recommended levels (Chu, Callaghan, Bish, & D'Angelo, 2009).

While low-income women have been historically regarded as at-risk for inadequate gestational weight gains (Hickey, 2000), the proportion of women gaining above IOM recommendations in this group has also increased. For example, among a sample of 622 rural white women living in New York State, Olson and Strawderman (2003) found that those with household incomes below 185% of the US federal poverty line were 2.5 times more likely to gain excessively in pregnancy than those women with higher incomes. Lederman, Alfasi, and Deckelbaum (2002) similarly found that 30 of 47 low-income, African-American women in New York City gained more than recommended by the IOM.

Little is known about predictors of excessive gestational weight gain among low-income women, especially racial/ethnic minorities who are particularly vulnerable to over-gain and chronic obesity (Gould Rothberg, Magriples, Kershaw, Rising, & Ickovics, 2011). This information is essential for the design of targeted interventions to prevent new or persistent obesity. While data from cohorts of predominately white, insured pregnant women have revealed several factors associated with excessive gestational weight gain, including high pre-pregnancy BMI (Althuizen, van Poppel, Seidell, & van Mechelen, 2009; Brawarsky et al., 2005; Olson et al., 2003; Stuebe, Oken, & Gillman, 2009; Wells, Schwalberg, Noonan, & Gabor, 2006), nulliparity (Brawarsky et al., 2005; Olson et al., 2003; Wells et al., 2006), poor diet quality (Olafsdottir, Skuladottir, Thorsdottir, Hauksson, & Steingrimsdottir, 2006; Stuebe et al., 2009), physical inactivity (Althuizen et al., 2009; Olson et al., 2003; Stuebe et al., 2009), smoking cessation (Favaretto et al., 2007; Olafsdottir et al., 2006), absent or incorrect clinician advice (Cogswell, Scanlon, Fein, & Schieve, 1999; Taffel, Keppel, & Jones, 1993; Tovar et al., 2010) and failure to have a gestational weight gain goal (Cogswell et al., 1999; Stotland et al., 2005; Tovar et al., 2010), only one study to date has examined the extent to which many of these same factors impact weight gain among urban, low-income, minority women (Gould Rothberg et al., 2011). Thus, we collected prospective data to: 1) describe modifiable mid-pregnancy behaviors and non-modifiable or early pregnancy factors in a group of urban, low-income, predominately African-American pregnant women; and 2) explore whether these variables are associated with excessive gestational weight gain.

Methods

Population and study design

Research subjects were participants in an ancillary study of Project BABIES, an ongoing prospective cohort study of pregnant women designed to examine the relationship between bacterial vaginosis and spontaneous preterm birth (Nelson, 2000). Recruitment began in July 2008 at five university-affiliated outpatient prenatal care clinics in Philadelphia, PA, the largest of which served primarily Medicaid-insured patients. Eligibility criteria included: < 16 weeks' gestation at enrollment, singleton pregnancy, English or Spanish fluency, and current residence in Philadelphia. Approximately 90% of women seen at the clinics have enrolled into Project BABIES, with a 5% refusal rate and a 5% missed rate. For our ancillary study, we additionally excluded women who were < 18 years of age or delivered a previous child before 35 weeks' gestation as these factors may affect gestational weight gain. Of the 139 women participating in the parent cohort who were approached between July 2009 and September 2010, 101 women (73%) were eligible and agreed to enroll in our ancillary study; these women completed additional behavioral assessments in mid-pregnancy (mean 21 weeks' gestation) and were followed until term to collect gestational weight gain data. Compared to participants enrolled in the larger, Project BABIES cohort, participants in our ancillary study were more likely self-identify as Black or African-American (83% vs. 67%), but equally likely to be nulliparous (46% vs. 46%) and complete some college or more education (13% vs. 16%). Mean age in years was similar in the two groups (23.3 years vs. 22.9 years). All participants provided written informed consent, and all procedures were in accordance with ethical standards for human experimentation. The institutional review board of Temple University approved the study protocol.

Excessive gestational weight gain

We calculated total gestational weight gain as the difference between last measured weight recorded before delivery and first measured weight in early pregnancy, both extracted from clinical prenatal care records. Similar to other studies among pregnant women (Olafsdottir et al., 2006; Olson, et al., 2003; Whitaker, 2004), we chose to use participants' first measured weight (before 14 weeks' gestation) as the proxy for maternal weight at conception because measured maternal pre-pregnancy weight is seldom available, self-reported pre-pregnancy weight varies by BMI and sociodemographic factors, and the total weight gain in the first trimester of pregnancy is small (0.5-2 kg). In our sample, we found systematic differences in pre-pregnancy weight recall by BMI; comparing self-reported pre-pregnancy weight to first measured weight before 10 weeks' gestation among 61 participants, mean weight difference was -0.9 kg among normal weight participants vs. -2.9 kg among overweight participants vs. -5.2 kg among obese participants (p=0.03). Eighty-seven (93%) participants had a first trimester weight available for analysis; 54% of whom had a measured weight before the ninth week of gestation, and 72% before the eleventh week. For the remaining women, whose initial measured weight ranged from 14 to 21 weeks' gestation, we created a regression model to predict first trimester prenatal weight. We considered three different approaches for estimation of first trimester weights: linear in time, quadratic in time, and a spline allowing for different slopes before and after 14 weeks gestation. In each model, a stochastic term was added to each observation with variance equal to the mean square error of the model. Correlations between estimated values and first observed weights were > 0.99

for those women with and without a first trimester measured weight. We therefore chose the most parsimonious model: linear in time with estimated error variance. Similar imputation approaches have been used in prior studies of low-income pregnant women (Olson et al., 2003), but these authors did not provide sufficient information to allow us to apply their equation with our data. Average gestational age of participants' last measured weight was 1.2 weeks (range 0-4 weeks) before delivery.

We defined excessive weight gain as gain greater than the upper limit for each woman's early pregnancy BMI category by IOM guidelines (2009). These guidelines recommend that women entering pregnancy with a normal BMI (18.5-24.9 kg/m^2) should gain 11.5–16 kg, that women with a BMI of <18.5 kg/m^2 should gain 12.5–18 kg, that women with a BMI of 25.0–29.9 kg/m^2 should gain 7–11.5 kg, and that women with a BMI of 30 kg/m^2 or greater should gain 5-9 kg.

Potential modifiable mid-pregnancy risk factors for excessive gestational weight gain

Diet—We collected information about dietary intake using a modified version of the PrimeScreen nutritional questionnaire (Rifas-Shiman et al., 2001), which included 14 questions about intake of food, food groups, and beverages. PrimeScreen is reproducible and comparable to estimates of intake from a validated full-length food frequency questionnaire for a number of food groups and nutrients (correlation coefficients ranged from 0.4 to 0.8). We have used the same version of the modified PrimeScreen questionnaire in other populations of pregnant women and found relationships between dietary patterns and weight-related outcomes (Tovar et al., 2010). A priori, we were most interested in examining obesity-related dietary behaviors identified in other populations (Boggs et al., 2011; Malik, Schulze, & Hu, 2006; Mozaffarian, Hao, Rimm, Willett, & Hu, 2011; Taveras et al., 2005), specifically intake of dairy, fruits and vegetables, potato chips, sugar-sweetened beverages, and fried or fast foods. Participants were asked to report the frequency of consumption over the last month using 5 categories: < 1x/week, 1x/week, 2-4x/week, nearly daily or daily, ≥ 2x/day. Because of small numbers in some response groups, we recoded categories as ≥ 1x/week vs. < 1x/week (for fried/fast food intake), or at least 2-4 times per week vs. < 1x/week (for intake of sugar-sweetened beverages, vegetables/fruits, dairy products, and potato chips).

Physical activity—Physical activity was assessed using questions adapted from the 2001 Behavioral Risk Factor Surveillance Survey (Macera et al., 2003). The 2001 physical activity questions have moderate to substantial evidence for test-retest reliability ([kappa] = 0.34-0.92) and fair to moderate evidence for validity (using the accelerometer or a physical activity log as the standard, [kappa] = 0.07-0.52) (Yore et al., 2007). We asked participants to recall overall frequency and duration of time spent in household, transportation, and leisure–time activities of light intensity (i.e., walking) and moderate-intensity (i.e., vacuuming, gardening, brisk walking, or bicycling) over the past month of pregnancy. Based on the American College of Obstetricians and Gynecologists (ACOG) guidelines for activity in pregnancy (ACOG Committee, 2002), participants were classified as active if they reported 30 or more minutes per day, five or more times per week, of light or moderate intensity activities.

Physical inactivity—To evaluate physical inactivity, we asked participants to report the average number of hours spent watching television or videos per day. We categorized women into two groups, those that watched < 2 hours of television daily vs. those that watched ≥ 2 hours of television per day, to be consistent with public health recommendations for television screen time (American Academy of Pediatrics, 2001).

Sleep—We asked participants to wear a wrist actigraph (Actiwatch-64 by Respironics) for 1 week in mid-pregnancy (mean 6 days), to allow for assessment of both weekend and weekday sleep patterns. The actigraph uses a highly sensitive accelerometer to measure gross motor activity, analyzed to identify sleep periods. Wrist actigraphy has a correlation of over 0.9 with polysomnography, the "gold standard" for measuring sleep (Jean-Louis et al., 1997). For this analysis, we were most concerned with nocturnal sleep duration, as previous studies in the general population have found a relationship linking nocturnal sleep reduction with weight gain (Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005). We categorized sleep into two categories (< 7 hours and ≥ 7 hours) to mirror previous studies (Facco, Grobman, Kramer, Ho, & Zee, 2010) and facilitate interpretation of the results.

Gestational weight gain goals—We assessed participants' gestational weight gain goals based on their response to the question, "When you first realized you were pregnant, did you have an idea in mind of how much weight you planned to gain during your pregnancy?" Participants who answered that they did have a goal were then asked, "About how much weight did you plan to gain?" Using IOM guidelines (2009), we categorized women's responses as concordant, discordant, or no goal.

Clinician advice—To assess clinician advice about gestational weight gain, participants were asked to report the amount of weight their doctor or nurse recommended they gain during this pregnancy. Similar to participants' weight gain goals, we categorized clinician advice as none, concordant, or discordant with IOM guidelines (2009).

Potential non-modifiable or early pregnancy risk factors for excessive gestational weight gain

Sociodemographic and medical factors—We collected information about maternal age, race/ethnicity, parity, employment status, and education at enrollment. Food security was assessed using the short form of the U.S. Household Food Security Survey Model (Blumberg, Bialostosky, Hamilton, & Briefel, 1999). Participants were categorized as food insecure if 2 or more questions were answered in the affirmative. Early pregnancy BMI was calculated from measured first trimester height and weight. We obtained information from the prenatal medical record about early pregnancy smoking status (former, current, or non-smoker) along with delivery date and mid-pregnancy ultrasound, which was used to calculate gestation length.

Data analysis

We first examined sociodemographics, medical factors, and modifiable mid-pregnancy behaviors according to IOM category of gestational weight gain, excessive vs. adequate/inadequate. We used Pearson chi-square tests, or Fisher's exact tests in the case of expected cell frequencies < 5, to examine differences in categorical variables. Independent t-tests were used to compare means for continuous variables. We calculated the unadjusted odds of excessive gestational weight gain for each level of a given characteristic in relation to a selected referent group.

Independent effects of modifiable mid-pregnancy behaviors and non-modifiable or early pregnancy factors on excessive gestational weight gain were studied using multivariable logistic regression. We used a backward elimination scheme to create the most parsimonious model, removing those variables not associated with gestational weight gain at the $p < 0.10$ significance level. Gestational age at delivery was constrained to remain in the model due to its strong relationship with the outcome in the literature. In a sensitivity analysis, we tested whether using only women with adequate gain as our referent group, rather than women with adequate or inadequate gain, altered our results.

Additionally, in a secondary analysis, we used multivariable linear regression to examine the relationship of total gestational weight gain with modifiable behaviors and non-modifiable or early pregnancy factors. As a measure of model fit, the adjusted R^2 was determined for the linear model. We used SAS version 9.2 (SAS Institute, Cary, NC) to carry out all analyses.

Results

Of the 101 women enrolled in our ancillary study, three were lost to follow-up. We excluded one woman who delivered twins and three women who delivered prior to 35 weeks' gestation, leaving 94 participants for this analysis. The characteristics of the study sample are shown in Tables 1 and 2. The majority of participating women were under the age of 25 years (73%, range 18 years to 42 years), African-American (83%), multiparous (54%), and unemployed (51%). All participants received Medicaid. On the basis of early pregnancy BMI values, 60% of women were overweight or obese and about one-third (32%) had a BMI ≥ 30 kg/m^2. In mid-pregnancy, 86% watched more than 2 hours of television per day, 33% participated in light or moderate activity for at least 30 minutes five or more times per week, and 56% slept less than 7 hours per night. The majority of women reported consumption of fried/fast food (82%) at least once per week. Ninety-four percent drank sugar-sweetened beverages (including juice, soda, or other drinks with sugar) at least 2-4 times per week. Fewer than one-quarter of women received clinician advice (19%) or had a gestational weight gain goal (18%) concordant with 2009 IOM guidelines.

Average gestational weight gain among study participants was 12.0 kg (standard deviation [SD] 6.8, range -4.1 kg to 27.7 kg). Approximately 28% of women gained below the IOM guidelines, 31% gained within the IOM recommended range, and 41% gained in excess. In bivariate analyses, women who exceeded gestational weight gain guidelines were more likely to be nulliparous and heavier in early pregnancy (Table 1). In mid-pregnancy, they were more likely to watch at least 2 hours of television per day, consume fried/fast food at least once per week, engage in physical activity less often, and have received clinician advice discordant with IOM recommendations (Table 2). Other sociodemographic characteristics, medical factors, and modifiable behaviors did not differ between IOM weight gain categories.

All measured sociodemographic, medical, and modifiable mid-pregnancy behavioral factors were considered for inclusion in a multivariable logistic regression model predicting excessive gestational weight gain. The final variables were: early pregnancy BMI, parity, clinician advice about weight gain, television viewing, and physical activity. High early pregnancy BMI, nulliparity, and discordant clinician advice were directly associated with gaining above IOM guidelines, with a trend toward decreased risk of excessive gain among women viewing fewer hours of television and engaging in regular physical activity during pregnancy (Table 3). None of the dietary factors were associated with gaining above IOM guidelines in our final model. In a sensitivity analysis, modeling risk factors for excessive gain compared with adequate gain led to slightly stronger associations of excess weight gain with regular activity and early pregnancy BMI, but otherwise did not materially change the results (data not shown). Additional analyses restricted to the 89 women in our sample who delivered after 37 weeks gestation also did not substantially differ from our current results.

Multivariable-adjusted predictors of total gestational weight gain using linear regression were similar to those of excessive gain. Women who were pregnant with their first child (3.24 kg; 95% CI: 1.28, 6.66) and received clinician advice discordant with IOM weight gain guidelines (4.30 kg; 95% CI: 0.07, 8.52) had significantly higher gestational weight gains than multiparous women and those who received clinician advice concordant with

IOM weight gain guidelines, respectively. Women who watched under two hours of television per day gained somewhat less than women who watched two or more hours of television daily (-3.24 kg, 95% CI: -7.00, 0.51). BMI remained associated with gestational weight gain, although higher BMI was associated with lower total gain (-3.06 kg, 95% CI: -5.70, -0.43). The final linear regression model, with the same sociodemographic, medical, and behavioral predictors included in Table 3, explained 21% (adjusted R^2) of the variance in gestational weight gain.

Discussion

In this prospective cohort study of low-income, predominately African-American pregnant women, excessive gestational weight gain was common, with nearly one-half of women gaining above current IOM guidelines. While prior studies among similar populations are sparse, our findings confirm and extend earlier work among Hispanic and non-Hispanic white women on non-modifiable or early pregnancy risk factors for excessive gestational weight gain. Several authors have reported that high early pregnancy BMI is a strong determinant of gaining above IOM guidelines, while mean weight gain is lowest among overweight or obese women (Althuizen et al., 2009; Chasan-Taber et al., 2008; Gould Rothberg et al., 2011; Olson et al., 2003; Stuebe et al., 2009). We also found that heavier women were more likely to exceed IOM guidelines despite lower mean gains, results that may be due in part to greater gestational weight gain restrictions for overweight or obese women compared to their normal weight counterparts (Institute of Medicine, 2009). Nulliparous women in our sample were more likely to gain above the IOM range than women with two or more births, findings that are consistent with data from a cohort of 1,100 predominately Hispanic and non-Hispanic white pregnant women in San Francisco (Brawarsky et al., 2005). While we did not find that early pregnancy smoking cessation was associated with higher gains, results that differ from previous studies on the topic ((Favaretto et al., 2007; Gould Rothberg et al., 2011; Olafsdottir et al., 2006), we were unable to determine the timing of tobacco abstinence prior to the index pregnancy which may have precluded our ability to find a relationship in this sample.

Modifiable mid-pregnancy behaviors were also associated with gestational weight gain, albeit some of these relationships were of marginal statistical significance in our small sample. Similar to data among non-pregnant and pregnant populations (Littman, Kristal, & White, 2005; Oken et al., 2007; Olson et al., 2003; Stuebe et al., 2009), we found a lower risk of weight gain among women who engaged in regular physical activity. While a recent meta-analysis of physical activity intervention trials revealed that exercise alone may be enough to lower total weight gain in pregnancy (Streuling et al., 2011), few women in our sample achieved ACOG guidelines for activity. Strategies to overcome known exercise barriers, including fatigue, concern with pregnancy complications, lack of time, lack of social support, and weather (Evenson, Moos, Carrier, & Siega-Riz, 2009), may need to be incorporated into weight control interventions in pregnancy. We found a trend toward decreased risk of excessive gain with watching less than two hours of television daily in our sample, results that have not been reported among pregnant women previously. Several observational studies among children and non-pregnant adults have described associations between television screen time and body weight, with clinical trial evidence confirming that reductions in television viewing lead to reductions in overweight (Swinburn & Shelly, 2008). Women who reported less than two hours of daily television screen time in our study were more likely to engage in regular physical activity than those viewing two or more hours of television (54% vs. 30%, p = 0.08), which may in part explain these results. Additionally, the association between discordant clinician advice and excessive weight gain that we describe confirms earlier work (Cogswell et al., 1999); however, we found a much higher proportion of women reporting no advice or discordant advice than previously published (81% vs. 53%, respectively). While it is possible that some clinicians in our sample may have addressed weight gain in late pregnancy, which would not have been captured in our questionnaires, low-income women may be at particular risk of limited/incorrect advice because of literacy barriers that promote poor physician-patient communication (Phelan et al., 2011). The high prevalence of limited/incorrect advice may also explain why so few women in our sample reported gestational weight gain goals concordant with IOM recommendations.

Contrary to data among non-pregnant and other pregnant populations linking higher intakes of sugary drinks, fried foods, and diary, and lower intakes of fruits and vegetables to weight gain and obesity risk (Malik et al., 2006; Mozaffarian et al., 2011; Olafsdottir et al., 2006; Stuebe et al., 2009), we did not find that diet quality was independently associated with excessive gestational weight gain. Using alternative cut-points to categorize the frequency of food or drink consumption did not change our results. It is possible that participants who were already struggling with too much or too little weight gain in mid-pregnancy may have changed their intake of these foods and beverages, explaining our null findings. Alternatively, differences in total energy intake may underlie these results; however, because PrimeScreen is a brief screening tool, it does not assess total energy intake well, and thus, we were unable to adjust for energy intake in our multivariable models. Further, the large proportion of overweight or obese women in our sample, who were already at the high end of unhealthy dietary behaviors, may have precluded our ability to find differences in dietary intake by IOM weight gain category. We also did not find that sleep was a risk factor for excessive gestational weight gain. Because we only focused on nocturnal sleep in this analysis, some women in our sample who took naps may have been misclassified as short sleepers, favoring the null hypothesis.

While our study is novel in that it describes modifiable and non-modifiable or early pregnancy predictors of excessive gestational weight gain among an underserved and understudied sample of women, several limitations exist. First, our findings are from a small prospective cohort study. Additional results from larger observational studies and randomized interventions, e.g. to improve clinician advice and maternal behaviors, will confirm the causality of the associations we observed. Second, despite our use of previously validated instruments to measure mid-pregnancy behaviors, all questionnaires are subject to bias. Due to budget limitations and participant burden, we were only able to collect an objective measurement of sleep duration in this study. Third, we assessed modifiable behaviors in mid-pregnancy, which may not reflect behaviors in early and late pregnancy. Fourth, we focused on television screen time as a measure of physical inactivity and may have missed a number of participants who were inactive due to time spent in front of the computer screen. Fifth, as we did not include clinician assessments in our study, participants may have incorrectly remembered or misunderstood clinician weight gain advice. Sixth, our small sample size precluded our ability to stratify our sample by early pregnancy BMI when exploring the relationships of modifiable predictors (particularly clinician advice and weight gain goals) with excessive weight gain. Future research studying larger samples of urban, low-income women are needed to explore potential interactions by BMI. Finally, we found a slightly lower rate of excessive gestational weight gain than had been previously reported among low-income, African-American women (Lederman et al., 2002), most likely due to our use of measured early pregnancy weights instead of self-reported pre-pregnancy weights to calculate gestational weight gain. Because we found systematic differences in pre-pregnancy weight recall by BMI, we believe our use of measured early weights is less prone to bias.

Implications

Given the paucity of prospective work among urban, low-income, minority pregnant women, our study provides important insight into predictors of excessive gestational weight gain. This information is critical to the design of effective weight control interventions among low-income, racial/ethnic minorities, for whom the prevalence of obesity is exceedingly high (Flegal et al., 2010). Pregnancy may be the opportune time for a weight control intervention, as pregnant women are especially receptive to behavior change recommendations, evidenced by the large number of smokers who quit during pregnancy (McBride, Emmons, & Lipkus, 2003). Future intervention studies should test the potential benefits of limited television viewing, regular physical activity, and accurate clinician advice during pregnancy to reduce the risk of excessive gestational weight gain. Strategies targeting nulliparous or overweight/obese women, who enter pregnancy already at a higher risk for excessive gain, may also help achieve healthier weight gains. These high risk women may especially benefit from counseling prior to pregnancy about healthy gestational weight gains, as data suggest that preconception counseling about a variety of pregnancy-related behaviors (e.g. smoking cessation, alcohol abstinence, folate intake) is associated with greater adoption of these behaviors during gestation (Elsinga et al., 2008). Our results posit that weight reduction prior to conception may be particularly helpful in reducing risk of over-gain, given the strong association between early pregnancy overweight/obesity and higher gains. Data in fact show that gastric banding patients gain significantly less weight in pregnancy post-surgery than pre-surgery, with better maternal and neonatal outcomes in the banded group (Dixon, Dixon, & O'Brien, 2005). A real challenge lies in capturing these high risk women before entering pregnancy (as most mothers do not present to their doctor until they've conceived) and in convincing them that weight loss is a priority, both of which require further study among urban, low-income mothers.

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Biography

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References

ACOG Committee. Opinion no. 267: exercise during pregnancy and the postpartum period. Obstetrics & Gynecology. 2002; 99:171–173. [PubMed: 11777528]

Althuizen E, van Poppel MN, Seidell JC, van Mechelen W. Correlates of absolute and excessive weight gain during pregnancy. Journal of Women's Health. 2009; 18:1559–1566.

American Academy of Pediatrics. Children, Adolescents, and Television. Pediatrics. 2001; 107:423–426. [PubMed: 11158483]

Blumberg SJ, Bialostosky K, Hamilton WL, Briefel RR. The effectiveness of a short form of the Household Food Security Scale. American Journal of Public Health. 1999; 89:1231–1234. [PubMed: 10432912]

Boggs DA, Palmer JR, Spiegelman D, Stampfer MJ, Adams-Campbell LL, Rosenberg L. Dietary patterns and 14-y weight gain in African American women. American Journal of Clinical Nutrition. 2011; 94:86–94. [PubMed: 21593501]

Brawarsky P, Stotland NE, Jackson RA, Fuentes-Afflick E, Escobar GJ, Rubashkin N, Haas JS. Pre-pregnancy and pregnancy-related factors and the risk of excessive or inadequate gestational weight gain. International Journal of Gynaecology & Obstetrics. 2005; 91:125–131. [PubMed: 16202415]

Brown WV, Fujioka K, Wilson PW, Woodworth KA. Obesity: why be concerned? American Journal of Medicine. 2009; 122(4 Suppl 1):S4–11. [PubMed: 19410676]

Chasan-Taber L, Schmidt MD, Pekow P, Sternfeld B, Solomon CG, Markenson G. Predictors of excessive and inadequate gestational weight gain in Hispanic women. Obesity. 2008; 16:1657–1666. [PubMed: 18451771]

Chu SY, Callaghan WM, Bish CL, D'Angelo D. Gestational weight gain by body mass index among US women delivering live births, 2004-2005: fueling future obesity. American Journal of Obstetrics & Gynecology. 2009; 200:271, e271–277. [PubMed: 19136091]

Cogswell ME, Scanlon KS, Fein SB, Schieve LA. Medically advised, mother's personal target, and actual weight gain during pregnancy. Obstetrics & Gynecology. 1999; 94:616–622. [PubMed: 10511369]

Davis EM, Zyzanski SJ, Olson CM, Stange KC, Horwitz RI. Racial, ethnic, and socioeconomic differences in the incidence of obesity related to childbirth. American Journal of Public Health. 2009; 99:294–299. [PubMed: 19059856]

Dixon JB, Dixon ME, O'Brien PE. Birth outcomes in obese women after laparoscopic adjustable gastric banding. Obstetrics & Gynecology. 2005; 106:965–972. [PubMed: 16260513]

Elsinga J, de Jong-Potjer LC, van der Pal-de Bruin KM, le Cessie S, Assendelft WJ, Buitendijk SE. The effect of preconception counselling on lifestyle and other behaviour before and during pregnancy. Women's Health Issues. 2008; 18(6 Suppl):S117–125. [PubMed: 19059545]

Evenson KR, Moos MK, Carrier K, Siega-Riz AM. Perceived barriers to physical activity among pregnant women. Maternal & Child Health Journal. 2009; 13:364–375. [PubMed: 18478322]

Facco FL, Grobman WA, Kramer J, Ho KH, Zee PC. Self-reported short sleep duration and frequent snoring in pregnancy: impact on glucose metabolism. American Journal of Obstetrics & Gynecology. 2010; 203:142, e141–145. [PubMed: 20510182]

Favaretto AL, Duncan BB, Mengue SS, Nucci LB, Barros EF, Kroeff LR, Vigo A, Schmidt MI. Prenatal weight gain following smoking cessation. European Journal of Obstetrics, Gynecology, & Reproductive Biology. 2007; 135:149–53.

Flegal K, Carroll MD, Ogden CL, Curtin LR. Prevalence and Trends in Obesity Among US Adults, 1999-2008. Journal of the American Medical Association. 2010; 303:235–241. [PubMed: 20071471]

Gangwisch JE, Malaspina D, Boden-Albala B, Heymsfield SB. Inadequate sleep as a risk factor for obesity: analyses of the NHANES I. Sleep. 2005; 28:1289–1296. [PubMed: 16295214]

Gore SA, Brown DM, West DS. The role of postpartum weight retention in obesity among women: a review of the evidence. Annals of Behavioral Medicine. 2003; 26:149–159. [PubMed: 14534032]

Gould Rothberg BE, Magriples U, Kershaw TS, Rising SS, Ickovics JR. Gestational weight gain and subsequent postpartum weight loss among young, low-income, ethnic minority women. American Journal of Obstetrics & Gynecology. 2011; 204:52, e51–11. [PubMed: 20974459]

Gunderson EP, Abrams B. Epidemiology of gestational weight gain and body weight changes after pregnancy. Epidemiologic Reviews. 2000; 22:261–274. [PubMed: 11218377]

Gunderson EP, Rifas-Shiman SL, Oken E, Rich-Edwards JW, Kleinman KP, Taveras EM, Gillman MW. Association of fewer hours of sleep at 6 months postpartum with substantial weight retention at 1 year postpartum. American Journal of Epidemiology. 2008; 167:178–187. [PubMed: 17971337]

Herring SJ, Rich-Edwards JW, Oken E, Rifas-Shiman SL, Kleinman KP, Gillman MW. Association of postpartum depression with weight retention 1 year after childbirth. Obesity. 2008; 16:1296–1301. [PubMed: 18369338]

Hickey CA. Sociocultural and behavioral influences on weight gain during pregnancy. American Journal of Clinical Nutrition. 2000; 71(5 Suppl):1364S–1370S. [PubMed: 10799414]

Institute of Medicine. Weight Gain During Pregnancy: Reexamining the Guidelines. The National Academies Press; Washington, DC: 2009.

Jean-Louis G, von Gizycki H, Zizi F, Spielman A, Hauri P, Taub H. The actigraph data analysis software: I. A novel approach to scoring and interpreting sleep-wake activity. Perceptual & Motor Skills. 1997; 85:207–216. [PubMed: 9293579]

Keppel KG, Taffel SM. Pregnancy-related weight gain and retention: implications of the 1990 Institute of Medicine guidelines. American Journal of Public Health. 1993; 83:1100–1103. [PubMed: 8342716]

Lederman SA, Alfasi G, Deckelbaum RJ. Pregnancy-associated obesity in Black women in New York City. Maternal & Child Health Journal. 2002; 6:37–42. [PubMed: 11926252]

Littman AJ, Kristal AR, White E. Effects of physical activity intensity, frequency, and activity type on 10-y weight change in middle-aged men and women. International Journal of Obesity. 2005; 29:524–533. [PubMed: 15672107]

Macera CA, Jones DA, Yore MM, Ham SA, Kohl HW, Kimsey CD, Buncher D. Prevalence of physical activity, including lifestyle activities among adults-United States, BRFSS 2000-2001. Morbidity and Mortality Weekly Report. 2003; 52:764–769. [PubMed: 12917582]

Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. American Journal of Clinical Nutrition. 2006; 84:274–288. [PubMed: 16895873]

McBride CM, Emmons KM, Lipkus IM. Understanding the potential of teachable moments: the case of smoking cessation. Health Education Research. 2003; 18:156–170. [PubMed: 12729175]

Melzer K, Schutz Y. Pre-pregnancy and pregnancy predictors of obesity. International Journal of Obesity. 2010; 34(Suppl 2):S44–52. [PubMed: 21151147]

Mozaffarian D, Hao T, Rimm EB, Willett WC, Hu FB. Changes in Diet and Lifestyle and Long-Term Weight Gain in Women and Men. New England Journal of Medicine. 2011; 364:2392–2404. [PubMed: 21696306]

Nelson, DB. [April 1, 2009] BV-Associated Bacteria and Adverse Pregnancy Outcomes among Urban Women. 2000. Available: http://projectreporter.nih.gov/project_info_description.cfm?aid=8061641&icde=0.

Ohlin A, Rossner S. Maternal body weight development after pregnancy. International Journal of Obesity. 1990; 14:159–173. [PubMed: 2341224]

Oken E, Taveras EM, Popoola FA, Rich-Edwards JW, Gillman MW. Television, walking, and diet: associations with postpartum weight retention. American Journal of Preventive Medicine. 2007; 32:305–311. [PubMed: 17383561]

Olafsdottir AS, Skuladottir GV, Thorsdottir I, Hauksson A, Steingrimsdottir L. Maternal diet in early and late pregnancy in relation to weight gain. International Journal of Obesity. 2006; 30:492–499. [PubMed: 16331301]

Olson CM, Strawderman MS. Modifiable behavioral factors in a biopsychosocial model predict inadequate and excessive gestational weight gain. Journal of the American Dietetic Association. 2003; 103:48–54. [PubMed: 12525793]

Phelan S, Phipps MG, Abrams B, Darroch F, Schaffner A, Wing RR. Practitioner advice and gestational weight gain. Journal of Women's Health. 2011; 20:585–591.

Rifas-Shiman SL, Willett WC, Lobb R, Kotch J, Dart C, Gillman MW. PrimeScreen, a brief dietary screening tool: reproducibility and comparability with both a longer food frequency questionnaire and biomarkers. Public Health Nutrition. 2001; 4:249–254. [PubMed: 11299098]

Stotland NE, Haas JS, Brawarsky P, Jackson RA, Fuentes-Afflick E, Escobar GJ. Body mass index, provider advice, and target gestational weight gain. Obstetrics & Gynecology. 2005; 105:633–638. [PubMed: 15738036]

Streuling I, Beyerlein A, Rosenfeld E, Hofmann H, Schulz T, von Kries R. Physical activity and gestational weight gain: a meta-analysis of intervention trials. BJOG: An International Journal of Obstetrics & Gynaecology. 2011; 118:278–284. [PubMed: 21134106]

Stuebe AM, Oken E, Gillman MW. Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. American Journal of Obstetrics & Gynecology. 2009; 201:58, e51–58. [PubMed: 19467640]

Swinburn B, Shelly A. Effects of TV time and other sedentary pursuits. International Journal of Obesity. 2008; 32(Suppl 7):S132–136. [PubMed: 19136983]

Taffel SM, Keppel KG, Jones GK. Medical advice on maternal weight gain and actual weight gain. Results from the 1988 National Maternal and Infant Health Survey. Annals of the New York Academy of Sciences. 1993; 678:293–305. [PubMed: 8494272]

Taveras EM, Berkey CS, Rifas-Shiman SL, Ludwig DS, Rockett HR, Field AE, Colditz GA, Gillman MW. Association of consumption of fried food away from home with body mass index and diet quality in older children and adolescents. Pediatrics. 2005; 116:e518–524. [PubMed: 16199680]

Tovar A, Guthrie LB, Platek D, Stuebe AM, Herring SJ, Oken E. Modifiable Predictors Associated with Having a Gestational Weight Gain Goal. Maternal & Child Health Journal. 2010; 15:1119–1126. [PubMed: 20711804]

Villamor E, Cnattingius S. Interpregnancy weight change and risk of adverse pregnancy outcomes: a population-based study. Lancet. 2006; 368:1164–1167. [PubMed: 17011943]

Wells CS, Schwalberg R, Noonan G, Gabor V. Factors influencing inadequate and excessive weight gain in pregnancy: Colorado, 2000-2002. Maternal & Child Health Journal. 2006; 10:55–62. [PubMed: 16496222]

Whitaker RC. Predicting preschooler obesity at birth: the role of maternal obesity in early pregnancy. Pediatrics. 2004; 114:e29–36. [PubMed: 15231970]

Yore MM, Ham SA, Ainsworth BE, Kruger J, Reis JP, Kohl HW 3rd, Macera CA. Reliability and validity of the instrument used in BRFSS to assess physical activity. Medicine & Science in Sports & Exercise. 2007; 39:1267–1274. [PubMed: 17762359]

Table 1

Frequencies and unadjusted associations of non-modifiable or early pregnancy factors with excessive gestational weight gain (GWG)

	Entire Sample n=94 [mean (SD) or %]	GWG Adequate or Inadequate n=55 (59%) [mean (SD) or %]	GWG Excessive n=39 (41%) [mean (SD) or %]	*Bivariate p value*	Excessive GWG	
					Unadjusted Odds Ratio	95% Confidence Interval
Age (years)				0.26		
< 25	73%	69%	79%		1.73	0.66, 4.55
≥ 25	27%	31%	21%		1.00	Referent
Race/ethnicity				0.72		
Black or African-American	83%	82%	85%		1.22	0.40, 3.70
Other	17%	18%	15%		1.00	Referent
Education				0.54		
High school or less	87%	85%	90%		1.49	0.42, 5.34
Some college or more	13%	15%	10%		1.00	Referent
Employment				0.39		
Employed (full- or part-time)	28%	24%	33%		1.40	0.54, 3.65
Unemployed	51%	51%	51%		1.00	Referent
Student	21%	25%	16%		0.60	0.20, 1.83
Food security				0.64		
Food insecure	26%	25%	29%		1.25	0.49, 3.21
Food secure	74%	75%	71%		1.00	Referent
Parity before index birth				0.03		
Nulliparous	46%	36%	59%		2.52	1.08, 5.84
Multiparous	54%	64%	41%		1.00	Referent
Early pregnancy BMI category				0.10		
≥ 25 kg/m^2	60% ^	53%	69%		2.02	0.85, 4.78
< 25 kg/m^2	40%	47%	31%		1.00	Referent
Early pregnancy smoking status				0.87		
Former smoker	27%	27%	26%		1.0	0.4, 2.5
Current smoker	8%	7%	10%		1.4	0.3, 6.3
Never smoker	65%	66%	64%		1.0	Referent
Gestational age at delivery (weeks)	38.8 (1.4)	38.6 (1.3)	39.0 (1.4)	0.24	1.20	0.88, 1.64

Table 2

Frequencies and unadjusted associations of modifiable mid-pregnancy behaviors with excessive gestational weight gain (GWG)

	Entire Sample n=94 [mean (SD) or %]	GWG Adequate or Inadequate n=55 (59%) [mean (SD) or %]	GWG Excessive n=39 (41%) [mean (SD) or %]	Bivariate *p* value	Excessive GWG	
					Unadjusted odds ratio	95% confidence interval
Physical activity (per week)				0.09		
Active *	33%	40%	23%		0.45	0.18, 1.13
Limited to no activity	67%	60%	77%		1.00	Referent
Television time (per day)				0.04		
< 2 hours	14%	20%	5%		0.22	0.05, 1.04
≥ 2 hours	86%	80%	95%		1.00	Referent
Sleep duration (per night) †				0.65		
< 7 hours	56%	58%	53%		1.22	0.52, 2.87
≥7 hours	44%	42%	47%		1.00	Referent
Sugar sweetened beverage intake (soda, juice, or sports drink, per week)				1.00 ‡		
≥ 2-4 servings (8 ounce)	94%	93%	95%		1.45	0.25, 8.34
< 2-4 servings (8 ounce)	6%	7%	5%		1.00	Referent
Vegetable or fruit intake (per week)				0.51 ‡		
≥ 2-4 times	89%	87%	92%		1.75	0.42, 7.24
< 2-4 times	11%	13%	8%		1.00	Referent
Dairy product consumption (per week)				0.98		
≥ 2-4 times	82%	82%	82%		1.02	0.35, 2.95
< 2-4 times	18%	18%	18%		1.00	Referent
Potato chip consumption (per week)				0.56		
≥ 2-4 times	61%	58%	64%		1.28	0.55, 2.99
< 2-4 times	39%	42%	36%		1.00	Referent
Fried or fast food intake (per week)				0.10		
≥ 1 time	82%	76%	90%		2.71	0.81, 9.06
< 1 time	18%	24%	10%		1.00	Referent
Weight gain goals				0.22		
Goal discordant with IOM guidelines	13%	11%	15%		3.25	0.66, 15.98

	Entire Sample n=94 [mean (SD) or %]	GWG Adequate or Inadequate n=55 (59%) [mean (SD) or %]	GWG Excessive n=39 (41%) [mean (SD) or %]	Bivariate *p* value	Excessive GWG	
					Unadjusted odds ratio	**95% confidence interval**
Goal concordant with IOM guidelines	18%	24%	10%		1.00	Referent
No goal	69%	65%	75%		2.69	0.79, 9.16
Provider advice about GWG				0.05		
Advice discordant with IOM guidelines	17%	9%	28%		3.46	0.84, 14.30
Advice concordant with IOM guidelines	19%	20%	18%		1.00	Referent
No advice	64%	71%	54%		0.85	0.29, 2.51

*Active defined as participation in light to moderate intensity physical activity, 30 or more minutes per day, 5 or more times per week.

†We had a small amount of missing data for sleep duration (6%).

‡Fisher's exact test two-sided *p* value used due to an expected cell frequency < 5.

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Table 3

Multivariable associations of significant modifiable mid-pregnancy behaviors and non-modifiable or early pregnancy factors with excessive gestational weight gain (GWG)

	Adjusted odds of excessive GWG* [Odds Ratio (95% Confidence Interval)]	*p* value
Early pregnancy BMI category		
≥ 25 kg/m^2	4.20 (1.43, 12.34)	0.01
< 25 kg/m^2	Referent	
Parity before index birth		
Nulliparous	3.35 (1.17, 9.62)	0.02
Multiparous	Referent	
Provider advice about GWG		
Advice discordant with IOM guidelines	5.88 (1.04, 33.32)	0.04
Advice concordant with IOM guidelines	Referent	
No advice	0.83 (0.25, 2.79)	0.76
Television viewing		
< 2 hours/day	0.18 (0.03, 1.03)	0.05
≥ 2 hours/day	Referent	
Physical activity		
Active†	0.35 (0.11, 1.09)	0.07
Limited to no activity	Referent	

*Additionally adjusted for gestational age at delivery.

†Active defined as participation in light to moderate intensity physical activity, 30 or more minutes per day, 5 or more times per week.